

## Preliminary Evaluation of Additional Green Field Sites in Nevada and California

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Additional green field sites (i.e. undeveloped sites without extensive existing tunnels and deep mines) in Nevada and California are evaluated with attributes articulated by the Technical Sub-Committee of the National Underground Laboratory Committee. The sites include 1) Charleston Peak between Las Vegas and Pahrump in Nevada, 2) Telescope Peak between Panamint Valley and Death Valley, California, 3) Mount Tom and Mount Morgan west of Bishop, California and 4) Boundary Peak of the White Mountains on the Nevada state line. This evaluation is a supplement to site development plans for the Homestake Gold mine, South Dakota and Soudan Iron Mine, Minnesota, both with vertical access; Carlsbad Waste Isolation Pilot Plant, New Mexico, with new shafts to greater depths; and Mt. San Jacinto, California, with new nearly horizontal tunneling.

A large number of potential sites for a national underground science laboratory exist in the California-Nevada region. The sites presented here were chosen to probe a range of options for a deep underground laboratory. This preliminary evaluation is premature to represent the sites for final proposals or in site selection. Naturally, these sites many not share some of the attributes of the San Jacinto site near Palm Springs, California – three of them are in more remote locations, for example. For the purpose of reexamining the options within the California-Nevada region we have attempted to locate sites that:

- 1) Present the opportunity for partnering with local and state governmental agencies in the construction of a mutually beneficial tunnel. This option follows the Gran Sasso model (the National Underground Laboratory of Italy) of sharing a highway tunnel with a scientific laboratory. To this end the **Charleston Peak** location was investigated.
- 2) Present very deep options, in excess of 3,000m (9,843 ft) of overburden (elevation difference between peak and portal of a horizontal tunnel). **Telescope Peak** near Death Valley represents this option for extreme depth using horizontal access.
- 3) Present the opportunity for assuming ownership of patented and unpatented claims and the use of existing mining and other permits for the expansion of an existing mining claim into a national underground laboratory. The soon-to-close **Pine Creek Mine**, while bordered by national forest land and wilderness regions in the California Sierras, presents a potential deep site with several of the permitting issues facing other proposed sites either already solved or only requiring modification of existing permits and not requiring entirely new permits.
- 4) Present an approximate analog to the Mt. San Jacinto proposal, but in a more mining-friendly state. The **Boundary Peak** site provides similar overburden opportunities, similar geological features, and comparable tunneling lengths, however located in Nevada.

The following table summarizes the four sites evaluated in this report. Additional maps, photographs, and profiles are attached at the end of the report after brief summaries of each site. It is stressed that a preliminary investigation of these sites is presented here, with as much information and supporting documentation as we could obtain within limited resources and time constraint.

### Additional Potential Sites for Locating a National Underground Science Laboratory

Peak, Underground Lab Location	Depth (m)	Elevation (m)	Tunnel Length (km)	Upward Grade	Orientation (deg. angle)
Nearly Horizontal Tunnel Portal					
<i>Inclined Tunnel Portal</i>					
<b>Las Vegas, Nevada</b>					
<b>Charleston Peak</b>	<b>1828</b>	<b>3633</b>			
Peak Spring Canyon, Pahrump		1707	9.7	1%	38
<i>Kyle Canyon, Highway 137</i>		<i>2073</i>	<i>8.5</i>	<i>3%</i>	<i>-6</i>
<b>Charleston Peak</b>	<b>2406</b>	<b>3633</b>			
Manse, Pahrump		1036	19.0	1%	26
<i>Kyle Canyon, Highway 137</i>		<i>2073</i>	<i>8.5</i>	<i>10%</i>	<i>-6</i>
<b>Death Valley, California</b>					
<b>Telescope Peak</b>	<b>2923</b>	<b>3367</b>			
Panamint Flat Dry Lake		323	12.1	1%	24
<i>Hanaupah Canyon, South Fork</i>		<i>1219</i>	<i>6.0</i>	<i>13%</i>	<i>15</i>
<b>Pine Creek Valley, California</b>					
<b>Mount Tom</b>	<b>2454</b>	<b>4161</b>			
Inyo National Forest, South of Royana		1646	6.1	1%	-137
<i>Pine Creek Mill</i>		<i>2469</i>	<i>4.9</i>	<i>16%</i>	<i>149</i>
<b>Mount Morgan</b>	<b>2521</b>	<b>4190</b>			
Inyo National Forest, Ranger Station		1573	9.7	1%	-155
<i>Pine Creek Mill</i>		<i>2469</i>	<i>5.6</i>	<i>14%</i>	<i>-63</i>
<b>Boundary Peak, Nevada</b>					
<b>Boundary Peak</b>	<b>1815</b>	<b>4005</b>			
Von Schmidt Line		2134	5.7	1%	-45
<i>Morris Creek</i>		<i>2170</i>	<i>5.2</i>	<i>0%</i>	<i>138</i>



### Site Attribute and Evaluation Approach

Depth (overburden thickness) of the proposed laboratory is the most important attribute of a site to be considered for the next generation of neutrino, nuclear science, and high energy physics experiments in the National Underground Science Laboratory. In addition to depth (required to shield cosmic rays), the sites need to be investigated for access mode (horizontal tunnel, inclined ramp, or vertical shaft), extent of new tunneling/excavation, radiation background (from radiochemical elements in the formation), construction feasibility and stability of large caverns, drainage, ventilation, seismic hazards, and other technical and operational considerations. The proximity to population centers and academic institutions, with the associated impact on science education for the next generation of students, is also a factor in evaluating the sites. This evaluation focuses on depths of underground chambers and lengths of access tunnels.

In this study, we choose 1,800 m (5,906 ft) as the minimum depth, measured from the peak to the test level accessible by a nearly horizontal (with 1% grade) tunnel. If a second tunnel is required, we can either excavate two parallel tunnels or excavate another shorter tunnel, using an inclined ramp. With monotonic decline from the underground laboratory to one portal, natural drainage can be maintained and the underground experiment chambers can be operated without costly pumping requirements. The portals at different elevations and different temperatures can also promote natural ventilation and reduce operational costs of forced ventilation. Because most mountain ranges are located in national forests, in wilderness areas, or in state or national park lands, the impact of a national underground facility was intentionally minimized and no shaft as an escape route through hoist and lift is considered. All portal sites evaluated here can be reached by four-wheel drive vehicles from routes identified on topographic maps by the National Forest Service and the United States Geological Service.

### Charleston Peak, Las Vegas

The eastern foothill of the Charleston Peak (elevation 3,633 m or 11,918 ft) in the Spring Mountains can be reached by Highway 137, 40 km (24 miles) from the outskirts of Las Vegas. Las Vegas is the fastest growing metropolitan area of the United States, with a population of ~1.4 million. The city of Pahrump is on the other side of Charleston Peak. Clark County (where Charleston Peak and Las Vegas are located) and the neighboring Nye County (where Pahrump and the Nevada Test Site are located) have extensive tunneling resources, expertise, and experienced work force for construction projects.

A nearly horizontal tunnel can start from the Peak Spring Canyon east of Pahrump, reach a cover of 1,828 m (6,000 ft) in 9.7 km (6.1 miles), and exit to connect to Highway 137 in 8.5 km (5.2 miles). Both portals are in the Humboldt-Toiyabe National Forests, and the peak is below the wilderness area. Additional overburden can be obtained at this location by shifting the portal down slope. It is possible to add approximately 600 m (1,969 ft) of cover if we double the tunnel length and move the starting portal ~10 km (6 miles) closer to Pahrump (on Bureau of Land Management land).

Charleston Peak in the Spring Mountains has regional inactive faults separating limestone blocks from other hard rocks. The presence of faults requires careful site characterization and mining operation to anticipate rock failure in crossing the faults. The seismic hazard is relatively low at this site in comparison with other green field sites. The new tunnel can be constructed as part of an extension of Highway 137 to connect Las Vegas with Pahrump. This concept of associating test site with highway is similar to the case at Gran Sasso, Italy where three large halls were constructed for physics experiments. The underground lab is easily accessible through the highway tunnel.

#### Telescope Peak, Death Valley

Telescope Peak (elevation 3,367 m or 11,048 ft) can provide the rock cover of 2,923 m (9,591 ft) through 12.1 km (7.5 miles) horizontal access from the Panamint Valley. The portal is located at the northern end of Panamint Flat Dry Lake (elevation of 323 m or 1,060 ft). Ballarat (a gold mining ghost town) is 16 km (10 miles) south of the potential portal site. This portal is in private land outside the Bureau of Land Management Wilderness area. The peak is below the Death Valley National Monument land.

The second portal can be a steep inclined ramp, with exit 6 km (3.7 miles) east at the South Fork of Hanaupah Canyon. With the steep slope, water will not drain into the Death Valley National Monument, with the lowest point in the United States, 71 m (282 ft) below sea level. If the water quality is good, the drainage may be portable for Panamint Valley with resort and other business interests. The closest (~97 km or 60 miles) airport to Panamint Valley is in Inyokern with services to Los Angeles. The airport is near the China Lake Naval Air Weapons Station and the town of Ridgecrest.

#### Mount Tom and Mount Morgan, Pine Creek Valley

Mount Tom (elevation 4,161 m or 13,652 ft) and Mount Morgan (elevation 4,190 m or 13,748 ft) are in the high Sierras west of Bishop, California. Both peaks can be accessed with nearly horizontal tunneling to achieve over 2,438 m (8,000 ft) of rock cover. Mount Tom can be accessed 6.1 km (3.8 miles) from a location in the Inyo National Forest. Mount Morgan is higher in elevation and requires longer tunneling (9.7 km or 6 miles) from a National Forest Ranger Station at the foothill of Wheeler Ridge. Pine Creek Valley is bounded on the north by Mount Morgan and Wheeler Ridge, and on the south by Mount Tom. Both mountains are composed primarily of granitic and metamorphic rocks.

Pine Creek Mine within Pine Creek Valley is referred to as the "Mine in the Sky", since it uses horizontal accesses to reach tungsten ores above the tunnels. The Easy Go tunnel at an elevation of 2469 m (8,100 ft) is 3.2 km (2 miles) long, heading north toward the ore bodies between Mount Morgan (granitic) and Wheeler Ridge (metamorphic). The shorter Brownstone tunnel (with length of 0.8 km or 2,500 ft) is oriented to the south. The first parts of these Pine Creek Mine tunnels, located at the Pine Creek Mill site, are potential portal locations for inclined escape tunnels. Part of the existing tunnels may be used for escape tunnels. If the ramps from Pine Creek Mill are too steep, we may use other

locations along the valley at lower elevations (and closer to the peak of Mount Tom) on national forest lands as exit points (for examples, the tailing ponds and the Scheelite site with gravel pits).

Observations from two existing tunnels from the Pine Creek Mill reveal many interesting features. The tunnels are wet at different locations, including the terminal end of the Easy Go tunnel, with ~1,219 m (4,000 ft) of overburden. The grade of ~0.5% is sufficient to drain large amount of seepage (millions of gallons per day, highest during spring runoffs along Morgan Creek). A long-standing arrangement to receive the ground water outflow exists with the local water control board. We observed that long sections of tunnel (hundreds of meters in length) do not require any rock or ground support, whatsoever. Natural ventilation is sufficient to maintain good air quality. Wide rooms (~25 m or 80 ft span), constructed decades ago, remain stable in stopes between the granite and marble structures. Radon gas control was needed during mining operations.

The mine has not been active for over ten years, with a diesel locomotive and the track still operational as of February 2001. The Pine Creek Mine is privately owned and is undergoing transfer of ownership for apparent salvage operations. The owner of the Pine Creek Mine was very open to discussions for scientific uses of the mine infrastructure. New tunnels may be treated as extensions of historical tunneling operations. The Pine Creek Mine has had decadal interactions with National Forest Services, Inyo County, and California Water Control Board. All of this information and mining experience are valuable for future tunneling development at these and similar sites and for dealing with permitting-granting agencies within forest, wilderness and publicly owned land in the West.

### Boundary Peak, Nevada

Boundary Peak, the highest point in Nevada (elevation 4,005 m or 13,140 ft), is located at the northern tip of the White Mountains, ~64 km (40 miles) north of Bishop along Highway 6. The peak is accessible from three sides to achieve a cover of ~1,800 m (6,000 ft). The nearly northwest to southeast oriented approaches, one along the von Schmidt line (the historic state line between Nevada and California) and the other from Morris Creek, are 5.7 km (3.5 miles) and 5.2 km (3.3 miles), respectively. Sections of the tunnels are below valleys of the same orientation. It is also possible to excavate below more smooth landform and have the tunnel oriented in the north to south orientation, starting from the Queen Canyon mining district (with five or more existing or historical mining operations) to reach the Boundary Peak. The rock in Boundary Peak and White Mountains is mainly sedimentary.

Boundary Peak in Nevada provides similar covers and comparable tunneling lengths as Mt. San Jacinto in California. Mt. San Jacinto provides covers of 1,786 – 2,325 m (5,859 – 7,628 ft) with 4.7 – 7.6 km (2.9 – 4.7 miles) of nearly horizontal tunnels. Both sites are accessed with tunnels below valley floors. For tunneling into high-relief cliff face with rugged landform, the excavation needs to be carefully planned with detailed geologic mapping, water flow and geo-chemical/isotopic analyses, and geo-technical evaluations

before and during mining operations. Unexpected delays in encountering hidden faults need to be avoided in any tunneling projects.

### Other Potential Sites

The Sierras have many majestic high peaks, including Mount Whitney, the highest point in the continental United States (elevation 4,418 m or 14,494 ft). Many peaks have high relief accessible from the valley floors to reach over 2,438 m (8,000 ft) rock covers. White Mountains can also provide over 2,438 m (8,000 ft) cover. The White Mountains Research Station of the University of California is located on the summit. The White Mountains, like Wheeler Ridge, has a relatively flat ridge over large areas. In Nevada, we also recognize that Mount Grant (west of an Army Depot in the town of Hawthorne), and Wheeler Peak (east of Ely in the Great Basin National Park) are potential sites with positive attributes.

### Summary

High-relief mountains are abundant in Nevada and California. An underground laboratory located at Charleston Peak near Las Vegas and at Boundary Peak on the Nevada-California state line could provide over 1,800 m (5,906 ft) of rock cover above test chambers. An additional cover on the order of 610 m (2,000 ft) could be added to Charleston Peak site if the portal is moved closer to Pahrump along a potential extension of Highway 137. Mount Tom and Mount Morgan could provide over 2,438 m (8,000 ft) of cover if the access tunnels were driven from flat land outside the Pine Creek Valley, with Pine Creek Mine tunnels as potential portals/extensions for escape tunnels. Mount Tom and Boundary Peak provide similar overburdens with comparable tunnel lengths as the Mt. San Jacinto site. Telescope Peak at Death Valley provides the greatest cover of 2,923 m (9,591 ft), among the sites evaluated. Systematic analyses of geologic, geotechnical, geohydrological and geochemical characteristics are needed to assess the technical, social-economical, and outreach-educational attributes in site selection for the next generation of science experiments.

### Acknowledgement

We gratefully acknowledge assistance and information provided by Jon Price and Joe Tingley of the Nevada Bureau of Mines and Geology, Jaak Daemen and Pierre Mousset-Jones of the Department of Mining Engineering, John Anderson of the Seismology Laboratory, and Jane Long of the Mackay School of Mines, University of Nevada at Reno. Preliminary discussions held with Nevada Bureau of Mines and Department of Mining Engineering of the University of Nevada at Reno reinforced the view that there exist many recent examples of tunneling projects with similar scale within Nevada, with a well understood permitting and approval process, and with a very likely strong support from the state for development of an underground science laboratory. We gratefully appreciate the information and hospitality extended by Jonathan Henry and Pete Belec of the Avocet Tungsten Inc. and Tom Crosby of Secor Inc. in the visit to the Pine Creek

Mine. Valuable discussions with John Apps and Harold Wollenberg of the Lawrence Berkeley National Laboratory are greatly appreciated.

Notes about Photos and Maps

The photographs were taken during a field trip to visit the sites, February 21 – 23, 2001. Each areal map covers an area of 22.5 minutes in longitude and 15 minutes in latitude. Each three-dimensional map covers the peak over 7.5 minutes in longitude and 7.5 minutes in latitude.

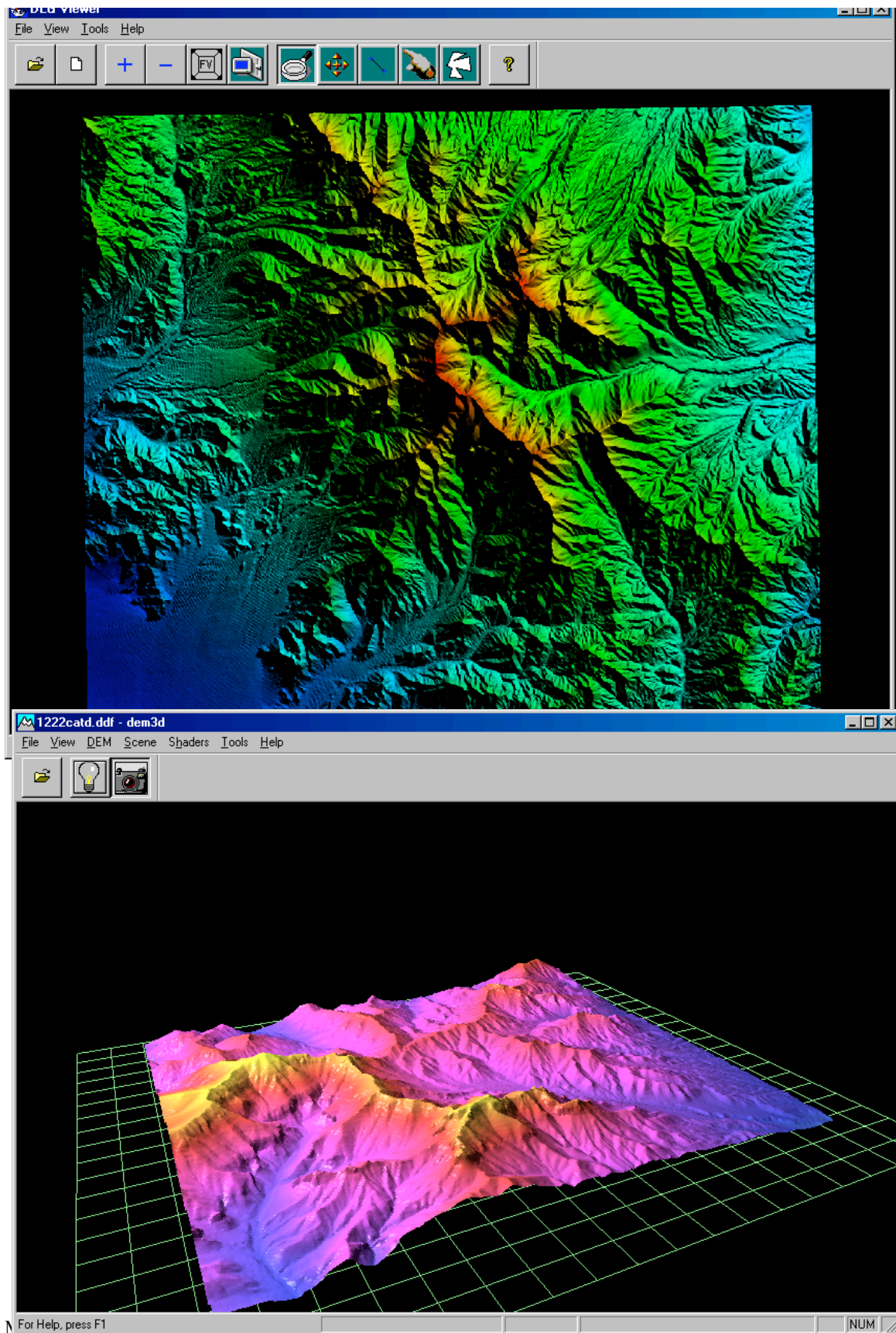


**Charleston Peak near Las Vegas viewed from the western slope near Pahrump, NV.**





### Isometric views of Charleston Peak, NV.

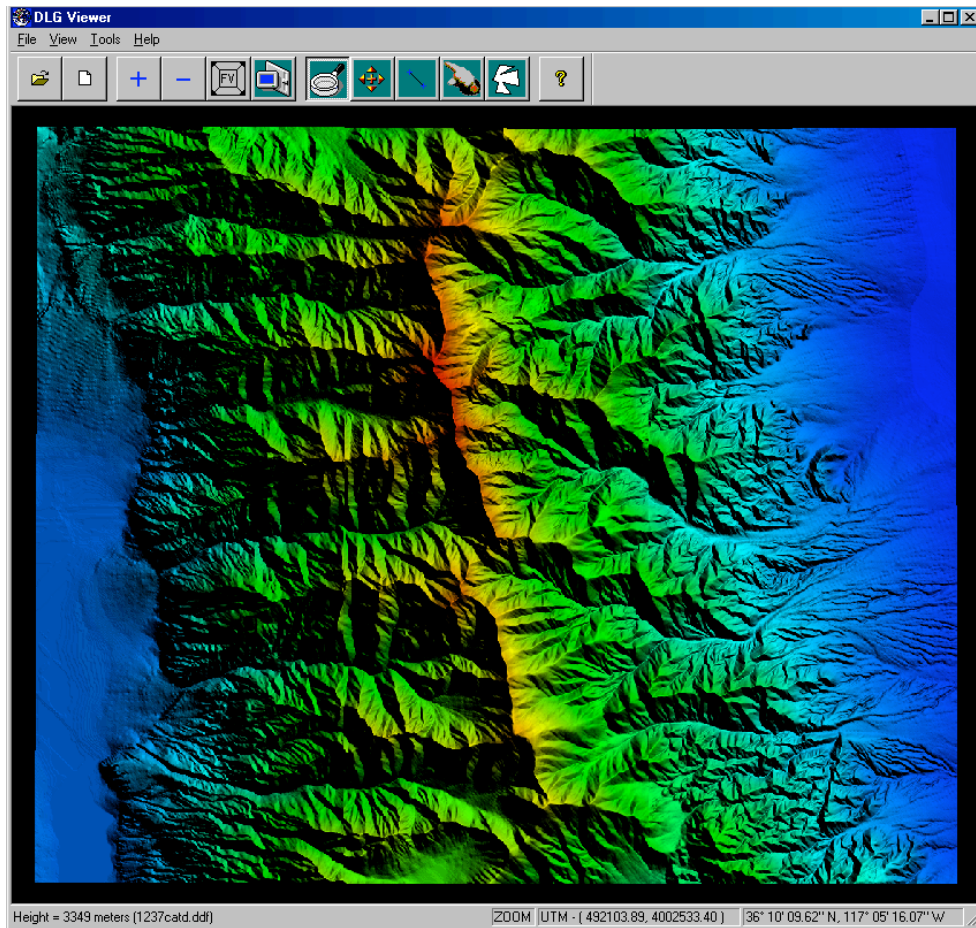




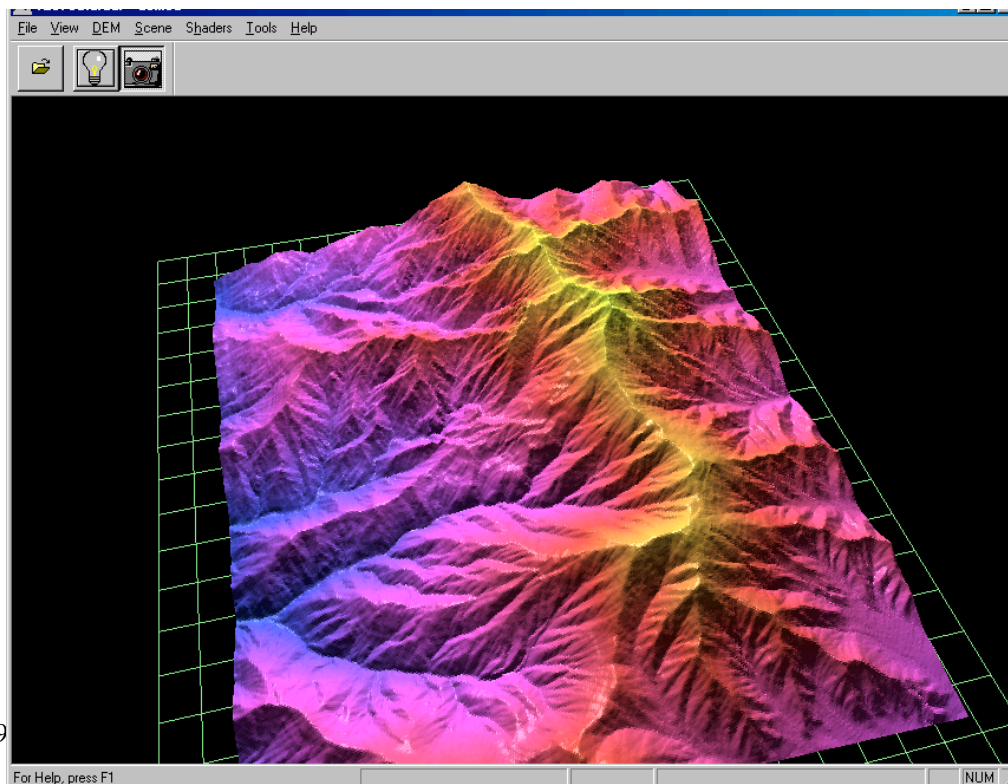
**Telegraph Peak, Death Valley viewed overlooking and inside the Panamint Valley.**







**Isometric views of Telescope Peak**



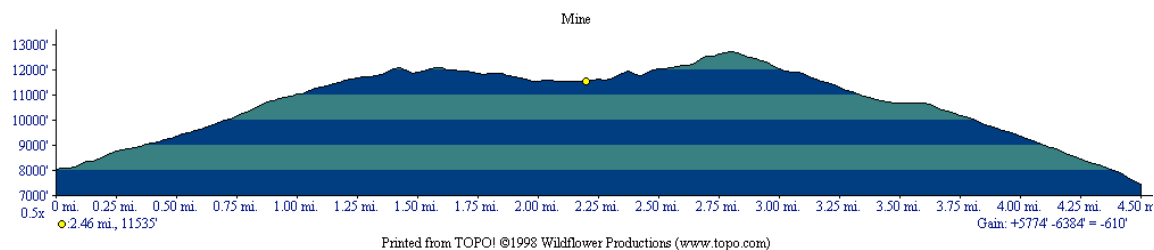
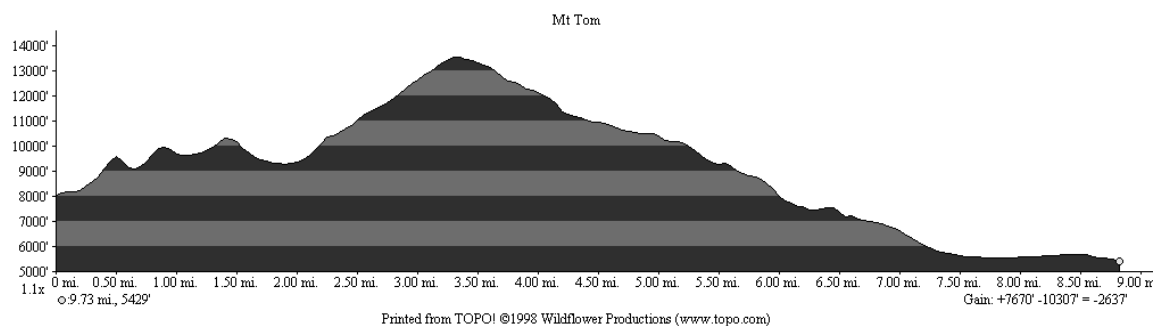
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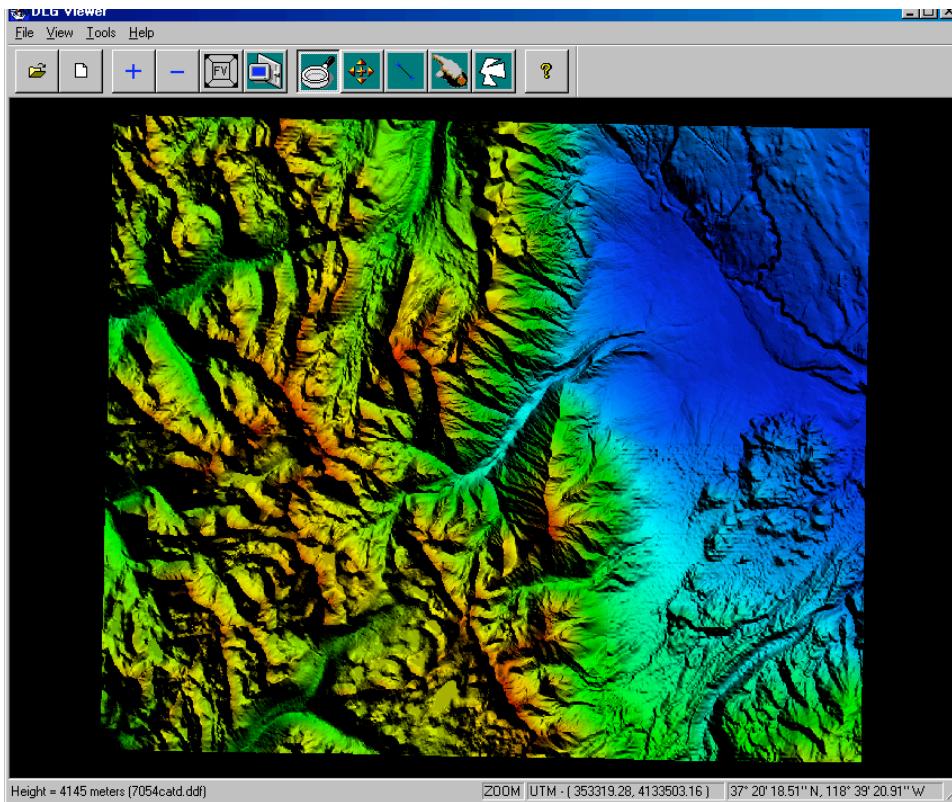
**Mount Tom, Pine Creek Valley  
Wheeler Ridge, Pine Creek Mine viewed from the East.**



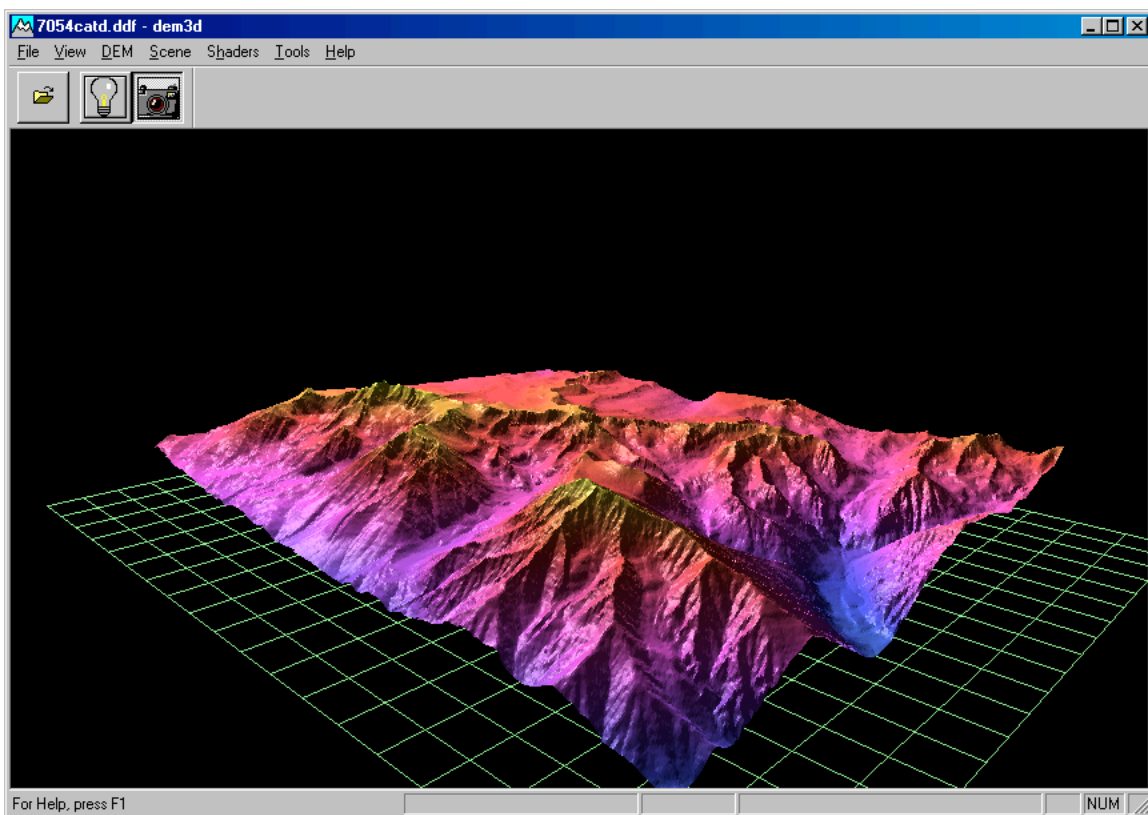
**Profiles of several possible tunnels under Mt. Tom and Wheeler Ridge.**







**Isometric Views of Mt. Tom and Wheeler ridge, near Bishop Ca.**





**Views from with Pine Creek Mine, notice the absence of ground support in the drift.**







**Ground water inside and near the entrance to Pine Creek and Brownstone Mines.**



## Boundary Peak, Nevada



Isometric Views of Boundary Peak.

